Technological Innovation and Labor Income Risk

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Motivation

- Human capital accounts for significant % of wealth
  - Traditional view: labor income safe, firms insure workers.
  - Modern view: quite risky and not diversifiable (from worker's perspective); possibly related to firm outcomes?
- What are the main drivers of risk? Our focus: innovation
  - Technological progress often involves creative destruction (Schumpeter, 1942): new firms / products / technologies displace existing ones.
  - If firms share profits with employees, part of the risk passed on to workers
  - Also, human capital may be displaced directly

This paper: New Facts

We combine direct measures of innovative activity from patent data and stock returns with data on worker earnings (SSA records)

New stylized facts about innovation and labor income risk:

1. Increased innovation at industry level associated with higher earnings risk, especially for top workers.
2. Relation driven by a combination of between and within firm effects:
   - Own firm innovation: higher mean, but also higher variance of earnings.
   - Innovation by competitors: lower mean and more negatively skewed earnings growth.

This paper: Model

- Key model ingredients:
  - Creative destruction: Innovation $\rightarrow$ increased dispersion in profitability.
  - Moral hazard: Workers receive share of profits; firm risk $\rightarrow$ worker risk
  - Skill displacement: New innovations can lower skilled worker productivity.
- Estimate model through indirect inference

This paper: Implications

- Innovation has significant welfare costs: a one-σ increase in industry innovation equivalent to a 1.5% perpetual consumption tax.
- Demand for insurance: a one-σ increase in industry innovation increases household marginal utility (SDF) by 0.4 log points.
  - Negative market price of risk for innovation shocks...
- Testable predictions supported by the data:
  - Left tail effects driven by separations and protracted unemployment spells
  - Own-firm displacement effects driven by process innovation (not product)
  - Own-firm displacement effects stronger for novel innovation

Outline

New Facts

Model

Model Predictions

Worker Earnings Data

- SSA data: 10% random sample of worker annual earnings.
  - Date range: 1980-2013; males, ages 25-58; minimum earnings level; exclude workers with substantial self-employment income
  - Workers matched to public firms based on highest earnings in given year. (Matched sample has 14m workers. Characteristics: Firms Workers)
- Construct age-adjusted income between periods t and $t+k$

$$w^i_{t,t+k} \equiv \log\left(\frac{\sum_{j=0}^{k} \text{W2 wage}_{i,t+j}}{\sum_{j=0}^{k} D(\text{age}_{i,t+j})}\right)$$

- Main outcome variable is growth in (cumulative) log earnings

$$Y_{i,t:t+h} \equiv w^i_{t+1,t+h} - w^i_{t-2,t}$$

Our specification emphasizes permanent income changes Details

Measuring technological innovation

- How to measure ‘technological innovation’ is not obvious
- Patents seem like a natural candidate. By definition, they relate to new inventions—though not all valuable inventions are patentable.
- More importantly, not all patents are equally valuable inventions.
  - proliferation of patents with no value (Jaffe & Lerner 2004)
  - pro-patent shift in US policy (Hall and Zeidonis 2001)
- Easy to come up with examples of not so useful patents.
- Need to weigh innovation outcomes by their economic value.
  - Kogan, Papanikolaou, Seru, and Stoffman (QJE, 2017) estimate the value of patents using firm’s stock market reaction to patent issues as an estimate of the (private) value of patents. KPSS value estimates correlate with measures of ‘scientific value’. Example Trading Volume Citations Placebo

Innovation and Risk: a First Look

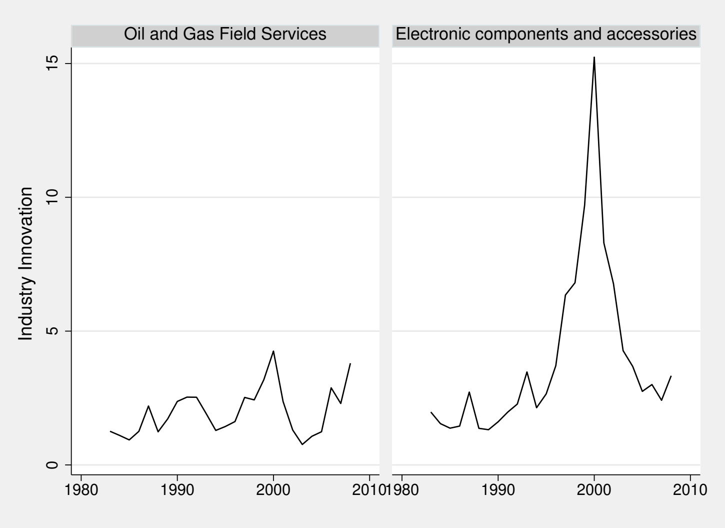
How does Industry innovation relate to firm and worker risk?

1. Aggregate market value of patents (KPSS) by industry:

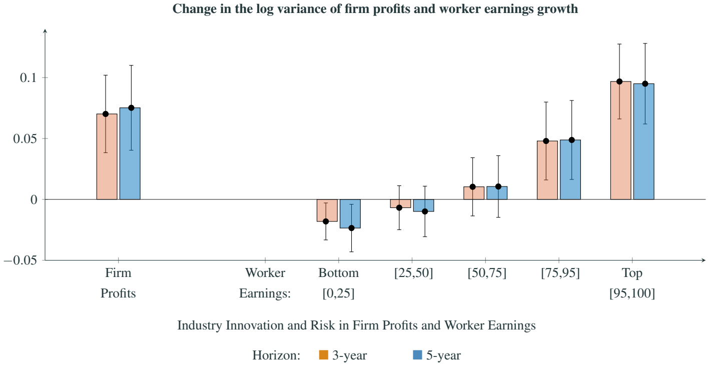
$$A_{I,t} = \frac{\sum_{f' \in I} \left(\sum_{j \in P_{f',t}} \xi_j \right)}{\sum_{f' \in I} K_{f't}}.$$

2. Firm risk:
   - Within SIC 3 digit industries, compute variance of future firm profits
   - Regress log variance on $A_{I,t}$
     (control for lag variance + industry, year FEs)
3. (Incumbent) worker risk:
   - Within SIC 3 digit industries, bin workers based on prior income and age
   - Compute variance of future worker earnings for each bin
   - Regress log variance on $A_{I,t}$
     (control for lag variance + interactions of industry, year, income, and age bin FEs)

Industry Innovation, example



Innovation, Firm and Worker risk



- One-σ increase in industry innovation → risk of firm profits ↑ by 7%
- Risk of worker earnings increases, especially for top workers (10%)
- Estimates comparable across horizons → persistent effects

Innovation and Risk: Own vs Competitor Innovation

- Examine separately effect of own vs competitor innovation:

$$Y_{i,t:t+h} = a_h \,\text{Firm Innovation}_{f,t} + b_h \,\text{Competitor Innovation}_{f,t} + c_h Z_{ft} + u_{ft+h}.$$

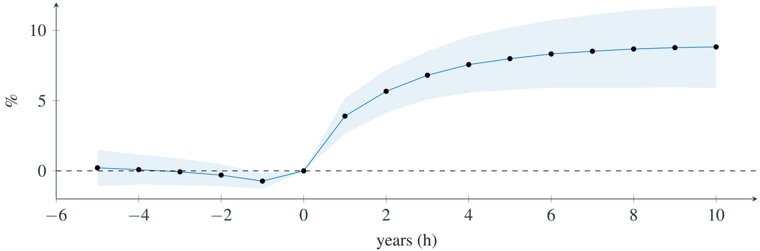
Firm Innovation: $A_{f,t} = \frac{\sum_{j \in P_{f,t}} \xi_j}{K_{ft}}$

Competitor Innovation: $A_{I \setminus f,t} = \frac{\sum_{f' \in I \setminus f} \left(\sum_{j \in P_{f',t}} \xi_j \right)}{\sum_{f' \in I \setminus f} K_{f't}}.$

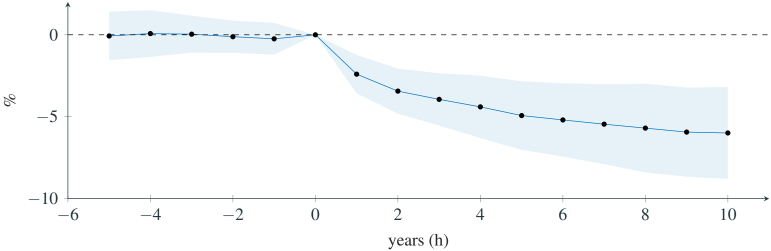
- Controls:
  - Firm-level regressions: firm size (assets); firm idiosyncratic volatility; industry; and time FE
  - Worker-level regressions: as above, plus flexible parametric functions of age; earnings rank within industry; earnings rank within firm; firm rank $\times$ polynomials in lagged income growth rates
- Weigh worker-level regressions by inverse of firm-year employment #

Innovation: Risk in Firm Profits

Profitability: Response to own innovation



Profitability: Response to competitor innovation



Firm profitability, worker earnings and innovation

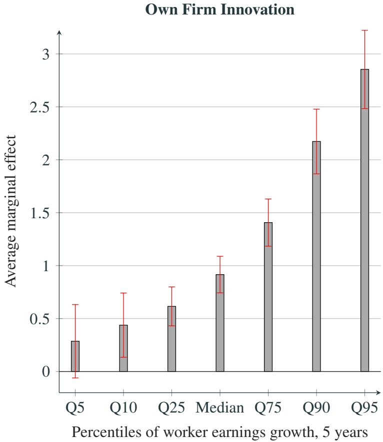
	A. Firm Profitability	B. Worker Earnings					
			Earnings Rank				
		All Workers	Bottom [0,25]	[25,50]	[50,75]	[75,95]	Top [95,100]
Firm Innovation,	7.99	1.38	1.19	1.09	1.40	1.85	1.53
market value (A_f^{sm})	(7.39)	(15.46)	(10.86)	(8.07)	(9.98)	(14.41)	(8.34)
Implied Elasticity		0.173	0.149	0.137	0.176	0.231	0.191
Competitor Innovation,	-4.93	-1.88	-1.92	-1.40	-1.01	-2.20	-5.92
market value ($A_{I\setminus f}^{sm}$)	(-7.81)	(-5.42)	(-6.41)	(-5.68)	(-3.91)	(-6.87)	(-11.90)
Implied Elasticity		0.381	0.39	0.284	0.204	0.444	1.201

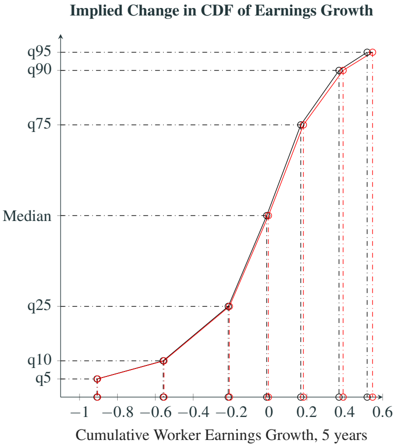
- own firm innovation $\rightarrow \uparrow$ firm profits and $\uparrow$ (incumbent) worker earnings
- competitor innovation $\rightarrow \downarrow$ firm profits and $\downarrow$ worker earnings
- Implied profit sharing elasticities larger on downside (0.38 vs 0.17)
- Magnitudes (mostly) larger for top workers

Risk and worker earnings

- Previous estimates correspond to wage growth for the ‘average’ worker.
  - But, benefits and costs need not be symmetrically distributed across incumbent workers.
  - Focusing on mean outcomes can be misleading
    - Especially if one interprets profit-sharing elasticities as a measure of insurance...
- We next model the how the entire conditional distribution of earnings shifts following innovation shocks using quantile regressions.

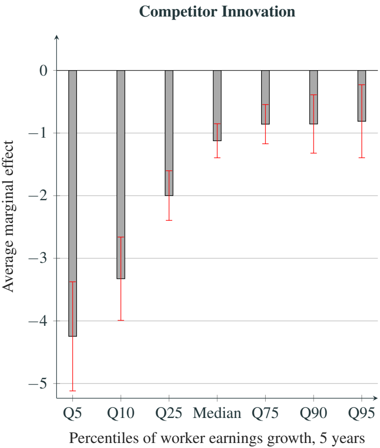
Response of Distribution of Earnings Growth Rates

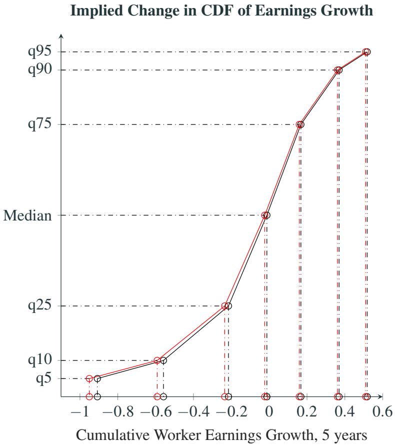




- All marginal effects for own innovation are positive:
  - cumulative distribution of earnings growth rates **shifts to the right**

Response of Distribution of Earnings Growth Rates



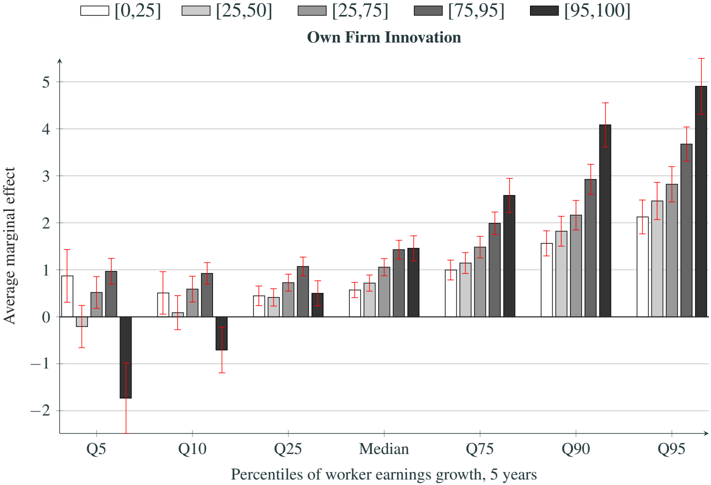


- All marginal effects for own innovation are negative:
  - cumulative distribution of earnings growth rates **shifts to the left**

Own innovation and earnings risk (by worker earnings level)

Estimates condition on past worker income

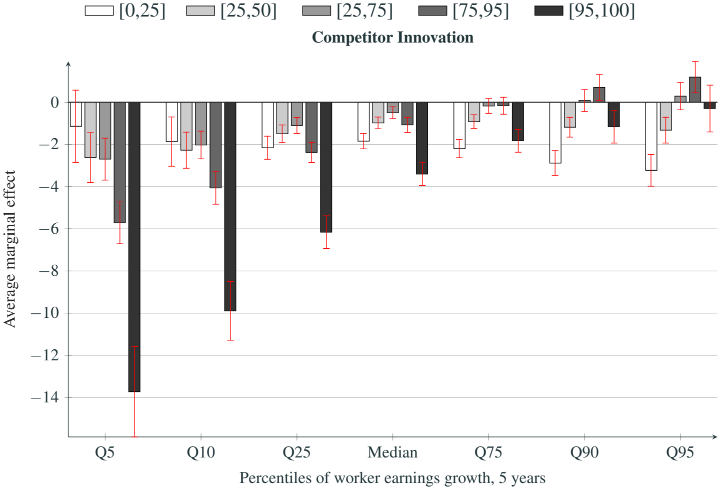
Colors indicate worker's initial earnings rank within the firm:

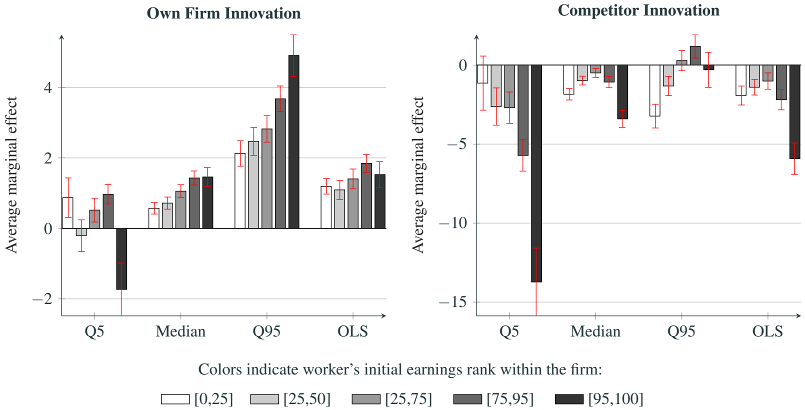


Competitor innovation and earnings risk (by worker earnings level)

Estimates condition on past worker income

Colors indicate worker's initial earnings rank within the firm:





- Top workers have higher exposure to innovation shocks
  - Own innovation: higher mean and variance
  - Competitor innovation: lower mean and higher skewness
  - Movements in left tail in response to competitor innovation comparable to difference between expansions–recessions (Guvenen, et al. 2014 Figure 10).

Summary

1. Increased innovation at industry level associated with higher earnings risk, especially for top workers.
2. Relation driven by a combination of between and within firm effects:
   - Own firm innovation: higher mean, but also higher variance of earnings.
     - Higher mean $\rightarrow$ role for profit sharing
     - Higher left tail $\rightarrow$ what is good for the firm need not be good for workers; role for skill displacement.
   - Innovation by competitors: lower mean and more negatively skewed earnings growth.
     - Lower mean $\rightarrow$ role for profit sharing
     - Negative skewness $\rightarrow$ role for job destruction

Outline

Setup

- Output X_t produced by a continuum of intermediate goods:

$$\log X_t = \int_0^1 \log x_{i,t} di$$

- Firms can produce each good using unskilled labor as an input l

$$x_{i,t} = q_{i,t} \, l_{i,t} \, e_{i,t} \, z_{i,t},$$

- Firms differ in efficiency q and ability of skilled worker (manager) z
- To induce high effort by manager ($e = 1$), firms share profits.
- CRS $\rightarrow$ only most efficient firm in each product line operates
- Firm profits / earnings of skilled worker proportional to

$$\left(1 - \frac{\bar{z}}{\kappa_{i,t} \, z_{i,t}}\right) X_t \, dt$$

  $\kappa_{i,t} \equiv q_{i,t}/\tilde{q}_{i,t}$ is the technology lead and $\bar{z} = 1$ is productivity of new hires

Innovation (own firm)

- Poisson rate of own firm innovation is $\lambda_{f,t} \in \{\lambda_L, \lambda_H\}$
- Transition rate matrix

$$T = \begin{pmatrix} -\mu_L & \mu_L \\ \mu_H & -\mu_H \end{pmatrix}.$$

- If own firm innovates:
  - Technology lead improves

$$\log \kappa_{i,t} = \log \kappa_{i,t-} + h$$

  - Incumbent worker gets new ability draw

$$\log z_{j,t} = \mu_z + \rho_z \log z_{j,t-} + \varepsilon_{j,t}, \qquad \varepsilon_{j,t} \sim N(0, \sigma_z^2).$$

- If $z_{j,t} < 1$, replaced with new hire
- Unemployed workers find new job at Poisson rate θ

Innovation (competitors)

- Poisson rate of competitor innovation is $\lambda_{f',t} \in \{\lambda_L, \lambda_H\}$, same T
- If competitors (potential entrants) innovate,
  - With probability $1-p$ innovation is small, technology lead shrinks

    $$\log \kappa_{i,t} = \log \kappa_{i,t-} - h$$

    but incumbent always keeps the lead ($\log \kappa_{i,t}$ cannot fall below ε)
  - With probability p innovation is radical: incumbent loses the lead
    - Successful entrant draws new κ (assuming new draw $\kappa'_{i,t} \geq \kappa_{i,t}\, z_{i,t}$)
    - Entrant hires new manager from unemployed pool at $z'_{i,t} = 1$
    - Incumbent manager joins unemployed pool
    - Previous incumbent firm now becomes potential entrant

Calibration

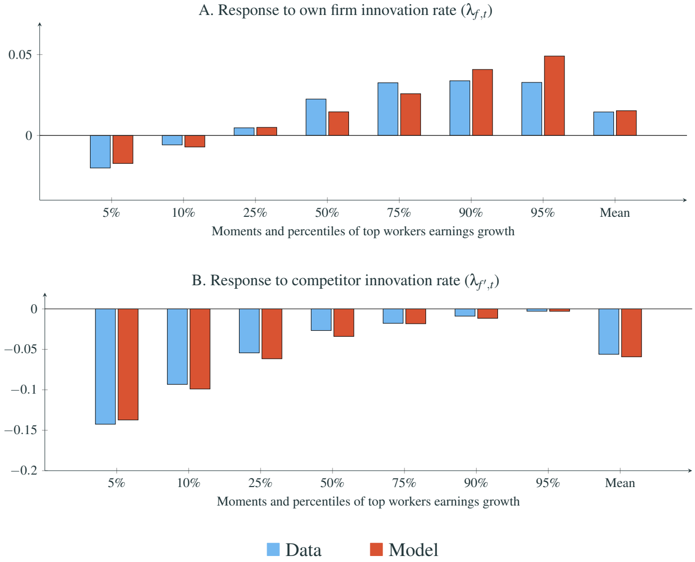
Calibrate (estimate) the model using indirect inference. Match:

- unconditional percentiles of top worker earnings growth
- response of percentiles to own and competitor innovation

Highlights:

Description	Parameter	Value
Persistence of (log) worker efficiency if innovation occurs	ρ_z	0.4126
Innovation rate (high state)	λ_H	1.7722
Innovation rate (low state)	λ_L	0.2991
Transition rate into high innovation state	μ_H	0.1293
Transition rate into low innovation state	μ_L	0.0821
Rate of radical innovation by competing firm	p	0.0561
Job finding rate	θ	3.091

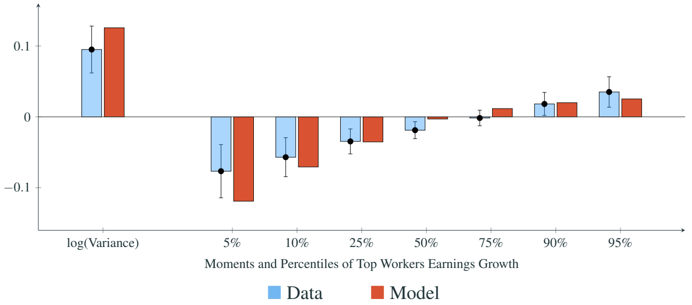
Innovation and Worker Earnings Risk: Model Fit



Industry Innovation and Earnings Risk: Model vs Data

Examine model's ability to match patterns of earnings risk at industry level.

In addition to variance, examine percentiles of earnings growth.



- Though not targeted explicitly, model matches the relation between earnings risk and industry innovation (a shock to average λ)

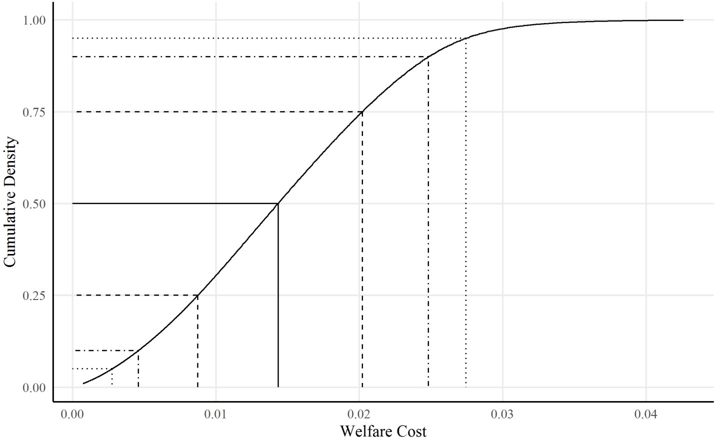
Preferences and Asset Markets

To calculate welfare costs and willingness to hedge, need more structure

- Preferences
$$\max_c E \int_0^\infty e^{-\rho t} \frac{c_t^{1-\gamma}}{1-\gamma} dt.$$
Baseline: $\gamma = 5$.
- Workers can self-insure by saving (but not borrowing) at riskless rate r
$$\begin{aligned} da_{j,t} &= [a_{it}\, r + y(s_{j,t}) - c_{j,t}]dt \\ a_{j,t} &\geq 0. \end{aligned}$$
- UI benefits: unemployed managers get 50% of lowest possible wage
- Progressive taxation:
$$y(s_{it}) = a\, w(s_{j,t})^{1-b},$$
We set $b = 0.181$ following Heathcote, Storesletten, and Violante (2017) and set a so to balance the budget.

Welfare costs

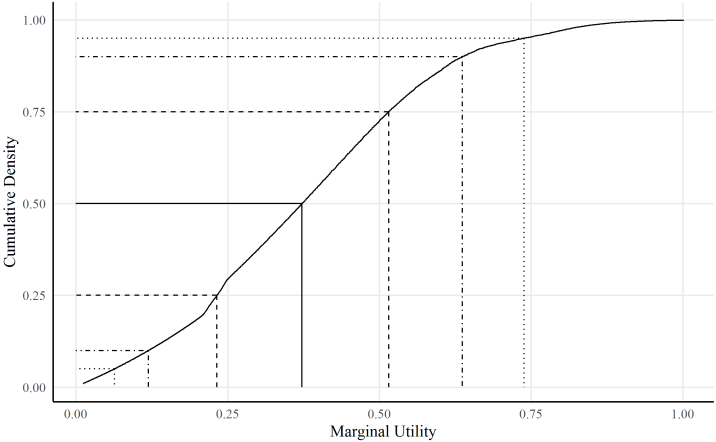
Utility loss following industry innovation



- A one-σ shock ∼ a 1.5% perpetual consumption decline (on average)
- Workers most at risk: high income, low assets

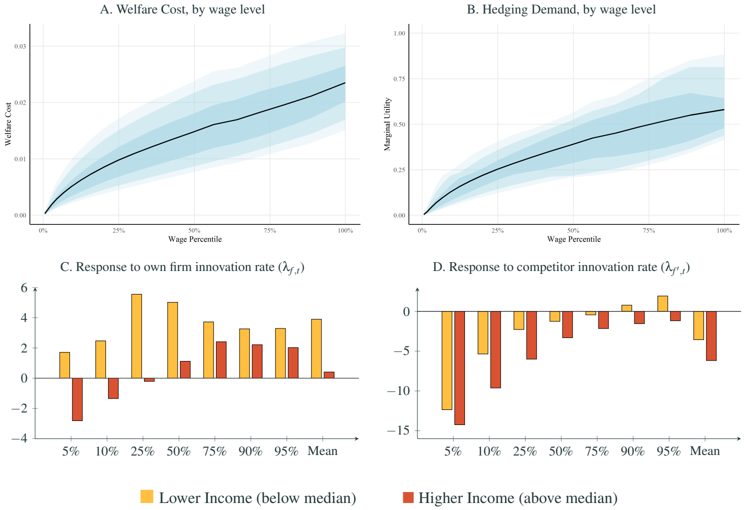
Demand for insurance

Response of MU to industry innovation shock



- A one-σ shock $\sim$ a 0.4 log point increase in MU (on average)
- Workers most willing to pay: high income, low assets

Model: Innovation risk higher for top workers



Outline

New Facts

Model

Model Predictions

Main Mechanisms / Predictions

- Vintage-specific human capital
  - Own firm left tail effects should be stronger for more novel innovations
  - Own firm left tail effects should be stronger for process innovation
- Job destruction: left tail driven by displacement/separations
  - Innovation should predict (extended) unemployment spells
  - Left tail effects should be larger for movers than stayers

Heterogenous Innovations

1. Process vs product Innovation

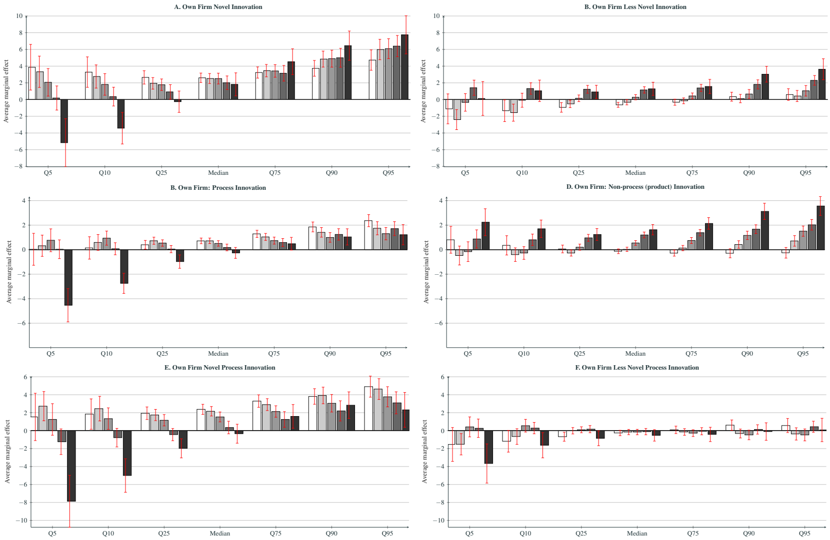
   - Bena and Simintzi (2019 identify patent claims that refer to process innovation as those which begin with 'A method for' or 'A process for'
   - Fraction of claims that can be classified as process: θ_j

$$\text{Define:} \qquad A^{\text{process}}_{f,t} = \frac{\sum_{j \in P_{f,t}} \theta_j \xi_j}{B_{ft}}$$

2. Novel vs not novel Innovation

   - Kelly, Papanikolaou, Seru, Taddy (2020) use text analysis to construct a pairwise distance measure (similarity) between two patent documents
   - For us, a novel patent $(N_j = 1)$ is dis-similar from the firm's prior patents

$$\text{Define:} \qquad A^{\text{novel}}_{f,t} = \frac{\sum_{j \in P_{f,t}} N_j \xi_j}{B_{ft}}$$



Colors indicate worker's initial earnings rank within the firm: ☐ [0,25] [25,50] [25,75] [75,95] [95,100]

Movers and Stayers: Model vs Data

Innovation and long-term unemployment

Two measures of long-term unemployment:

1. Number of years with zero W2 earnings
   - Sample excludes workers with any self-employment income, so these are not ‘entrepreneurs’
2. Likelihood of applying for disability insurance
   - Conditional applicants: Many workers eligible for DI choose to work if labor market opportunities are good (Autor and Duggan, 2003)
   - If technology displaces human capital, might expect more SSDI applications
   - Top workers have lower replacement rates and baseline propensity to apply. But, since SSDI payments are risk-free, they might apply if (perceived) labor income risk rises.

Innovation and long-term unemployment

A. Number of years unemployed, 5yr horizon

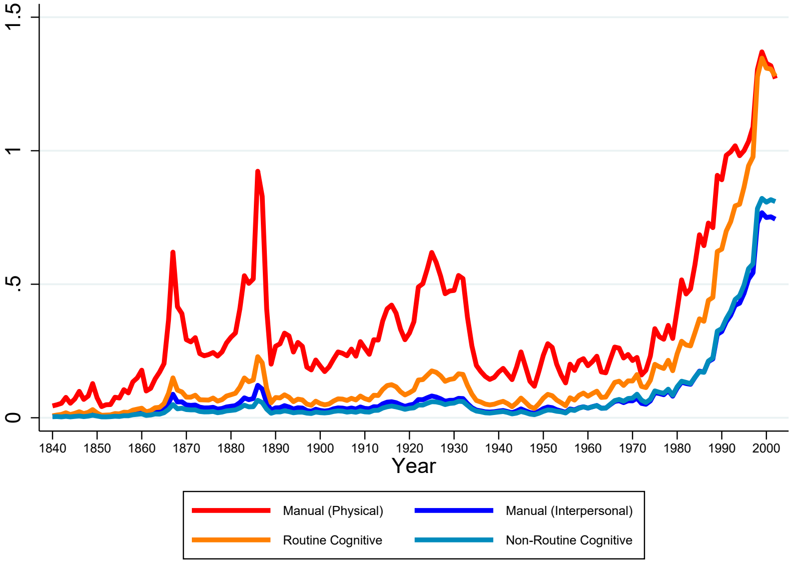
Innovation	Worker earnings rank				
	[0,25]	[25,50]	[50,75]	[75,95]	[95,100]
Innovation by the firm, A_f	-0.28	0.55	0.43	0.61	1.06
	[-2.58]	[6.32]	[4.96]	[4.40]	[5.44]
Innovation by competitors, $A_{I \setminus f}$	-0.73	0.49	1.42	2.07	2.17
	[-3.55]	[3.08]	[9.20]	[10.33]	[8.36]

B. Application for disability insurance (DI), 5yr horizon

Innovation	Worker earnings rank				
	[0,25]	[25,50]	[50,75]	[75,95]	[95,100]
Innovation by the firm, A_f	-0.11	0.02	0.04	0.05	0.08
	[-6.56]	[1.46]	[3.92]	[6.03]	[7.05]
Innovation by competitors, $A_{I \setminus f}$	-0.35	-0.16	0.02	0.18	0.19
	[-8.70]	[-5.41]	[0.76]	[7.35]	[5.87]

Summary

- Technological innovation associated with higher income risk.
  1. Creative destruction + profit sharing
  2. Human capital displacement
- Significant welfare costs and hedging demand. Implications
  - Asset Pricing: workers want to buy assets that do well during periods of aggregate innovation (growth)
  - Macro: welfare costs higher than costs of business cycles (with job loss)
- Next step:
  - Kogan, Papanikolaou, Schmidt, Seegmiller, 2020), use textual analysis to link patents to occupations
  - Offer a long run perspective, using long sample back to 1850.
  - Evidence for a displacement channel using survey and administrative data on worker earnings.



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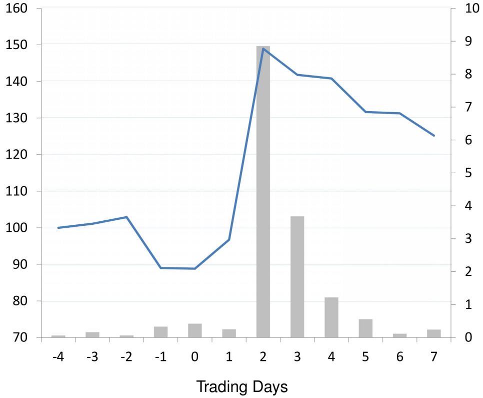
Manual (Interpersonal)
Routine Cognitive
Non-Routine Cognitive

THANK YOU

Stock market and patent issues



- **Stock price (left axis) and trading volume (right axis) of GENEX Co on August 7, 1990, after award of patent no. 4,946,778 for ”Single-Chain Polypeptide Binding Molecules”** Back

Share turnover during patent issuance weeks

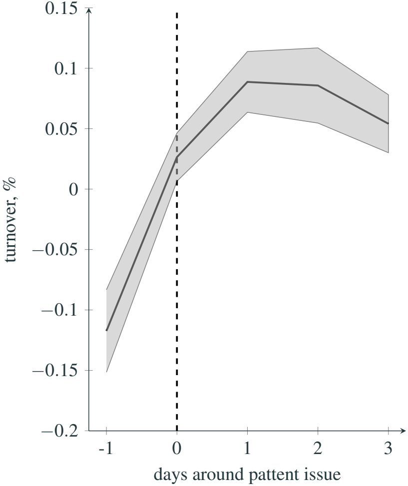


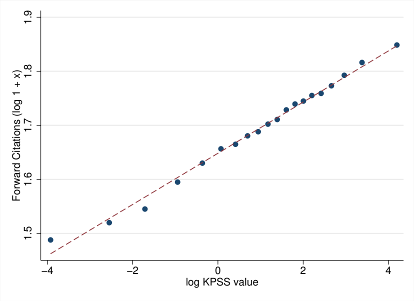
Figure plots the share turnover around patent issuance days. Share turnover h is the ratio of daily volume (CRSP: vol) to shares outstanding (CRSP: shrout). The median daily share turnover is 1.29%. We report the coefficient estimates b_l, $l = -1 \ldots 3$, (and 90% confidence intervals) from the following specification:

$$h_{fd} = a_0 + \sum_l b_l I_{fd+l} + c Z_{fd} + \varepsilon_{fd},$$

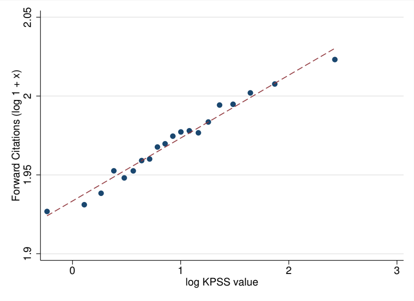
where the indicator variable I takes the value one if firm f is issued a patent on day d; the vector of controls Z_{fd} includes firm-year and calendar day fixed effects. Standard errors are clustered by year.

Back

Forward citations and patent market value



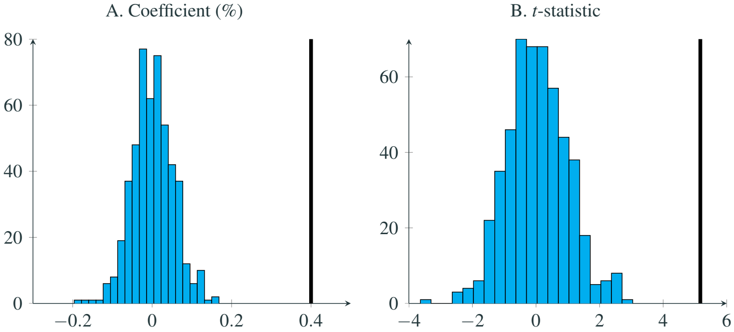
Issue year controls



Issue year, Tech class, Firm Char, Firm FE controls

Figure plots the cross-sectional relation between forward patent citations and the estimated market value of patents. We group the patent data into 100 quantiles based on their cohort adjusted citations $(1+C/\bar{C})$. The horizontal axis plots the log of average cohort adjusted patent citations in each quantile. The vertical axis plots the logarithm of the average patent value in each quantile (scaled by the average value of patents granted in the same year). Back

Relation between stock market reaction and number of citations across placebo experiments



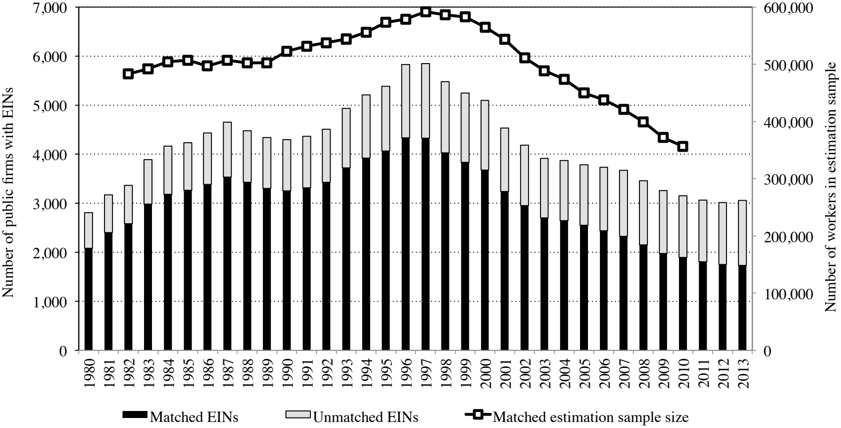
Note: Figure plots distribution of estimated coefficients $\hat{b}$ (panel A) and t-statistics (panel B), from estimating equation linking forward citations and estimated patent values (with full set of controls) across 500 placebo experiments. In each placebo experiment, we randomly generate a different issue date for each patent within the same year the patent is granted to the firm. We then reconstruct our measure using these placebo grant dates. The solid line on the right corresponds

Interpreting the dependent variable

- Sum over multiple years for two reasons:
  1. mitigate problem with observations with zero income when using year-on-year growth rates
  2. smooths large changes in earnings that may be induced by large transitory shocks $\rightarrow$ more emphasis on persistent earnings
- To see 2, suppose that annual log income (net of age effects) is sum of:
  - permanent random walk component: $\xi_{i,t} = \xi_{i,t-1} + \eta_{i,t}$
  - iid, mean zero, transitory component: $\varepsilon_{i,t}$
- A log-linear approximation of $Y_{i,t:t+5}$ around zero is:

$$\begin{aligned} Y_{i,t:t+5} \quad &\approx \quad \frac{1}{5}\eta_{i,t+5} + \frac{2}{5}\eta_{i,t+4} + \frac{3}{5}\eta_{i,t+3} + \frac{4}{5}\eta_{i,t+2} + \eta_{i,t+1} + \frac{2}{3}\eta_{i,t} + \frac{1}{3}\eta_{i,t-1} \\ &+ \quad \frac{1}{5}\left[\varepsilon_{i,t+5} + \varepsilon_{i,t+4} + \varepsilon_{i,t+3} + \varepsilon_{i,t+2} + \varepsilon_{i,t+1}\right] - \frac{1}{3}\left[\varepsilon_{i,t} + \varepsilon_{i,t-1} + \varepsilon_{i,t-2}\right]. \end{aligned}$$

Characteristics of the matched sample



- Exclude financials and utilities ⇒ 11.4 million matched observations
- Matching rates are roughly constant across major SIC industries
- Somewhat less likely to find matches for larger firms

Firm-level summary stats

Table 2: Firm descriptive statistics: matched vs non-matched sample

	Obs	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%
A. Matched sample												
Employment ('1000s)	101,980	6.64	29.04	0.01	0.02	0.05	0.15	0.64	3.15	12.50	28.30	108.00
Employment (SSA, '1000s)	104,071	2.52	12.14	0.00	0.01	0.01	0.06	0.23	1.03	4.19	9.93	42.23
Book assets, log	104,068	4.66	2.14	0.42	1.34	1.94	3.14	4.52	6.07	7.57	8.45	10.02
RD to assets	65,217	0.10	0.15	0.00	0.00	0.00	0.01	0.05	0.12	0.24	0.38	0.77
ROA	103,703	-0.02	0.29	-1.31	-0.58	-0.30	-0.02	0.07	0.12	0.17	0.20	0.29
Firm Innovation	104,068	0.05	0.16	0.00	0.00	0.00	0.00	0.00	0.01	0.12	0.27	0.80
Firm innovation, process	104,068	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.30
Firm innovation, non-process	104,068	0.03	0.10	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.16	0.46
B. Non-Matched sample												
	Obs	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%
Employment ('1000s)	37,397	9.52	46.51	0.00	0.01	0.04	0.19	1.10	4.90	18.80	41.00	133.00
Book assets, log	38,663	5.33	2.25	0.59	1.62	2.30	3.71	5.34	6.93	8.27	9.10	10.40
RD to assets	18,712	0.07	0.13	0.00	0.00	0.00	0.00	0.02	0.07	0.18	0.29	0.68
ROA	38,433	0.00	0.26	-1.25	-0.47	-0.21	0.00	0.07	0.12	0.17	0.21	0.30
Firm Innovation	38,663	0.02	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.12	0.54
Firm innovation, process	38,663	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.24
Firm innovation, non-process	38,663	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14

Note: Table reports univariate summary statistics for the sample of matched (Panel A) and unmatched (Panel B) public firms. The unit of analysis is the GVKEY-year.

Worker-level summary stats

Table 1: Worker descriptive statistics: Full versus matched sample

	Obs	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%
Panel A. Matched sample												
Wage (in 2013 dollars)	14,621,600	74,199	146,577	4,826	15,855	24,321	39,273	57,577	82,765	123,248	165,383	343,534
Age	14,621,600	39.6	8.0	26.0	27.0	29.0	33.0	39.0	46.0	51.0	53.0	54.0
Firm tenure	14,621,600	6.2	5.2	1.0	1.0	1.0	2.0	5.0	9.0	14.0	17.0	23.0
Firm tenure $\geq$ 3 years	14,621,600	0.7	0.4	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0
Cumulative 3-year wage growth	14,593,617	-0.07	0.59	-2.31	-0.88	-0.53	-0.17	-0.01	0.13	0.38	0.58	1.10
Left firm after 1 year	14,621,600	0.15	0.36	0	0	0	0	0	0	1	1	1
Left firm after 3 year	14,621,600	0.34	0.47	0	0	0	0	0	1	1	1	1
Panel B. SSA worker sample (based on 10% sample)												
	Obs	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%
Wage (in 2013 dollars)	110,927,670	58,190	121,135	2,729	7,836	13,803	26,471	43,366	65,982	100,271	138,168	313,623
Age	103,635,050	38.9	8.1	26.0	27.0	28.0	32.0	39.0	46.0	51.0	52.0	54.0
Firm tenure	110,762,520	5.1	4.7	1.0	1.0	1.0	2.0	3.0	7.0	12.0	15.0	21.0
Firm tenure $\geq$ 3 years	110,762,520	0.6	0.5	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0
Cumulative 3-year wage growth	103,635,050	-0.09	0.65	-2.63	-1.08	-0.64	-0.21	-0.01	0.15	0.43	0.66	1.26
Left firm after 1 year	110,540,010	0.25	0.43	0	0	0	0	0	0	1	1	1
Left firm after 3 year	110,016,540	0.45	0.50	0	0	0	0	0	1	1	1	1

Note: Table reports univariate summary statistics for the sample of matched (Panel A) and unmatched (Panel B) worker-level measures. The unit of analysis is the SSN-year.

- Manufacturing workers over-represented (exclude industries w/o patents)

Comparison: expansions vs recessions (GOS, 2014)

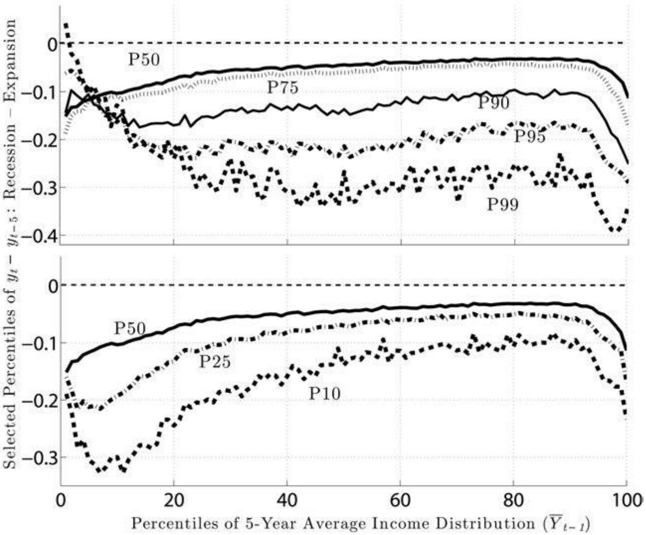


FIG. 10.—Cyclical change in the percentiles of 5-year earnings growth distribution

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